Effects of temperature change on hydropower generation in snowmelt runoff basins

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Abstract. Hydropower generation depends on incoming streamflow (energy supply) and regional energy consumption (energy demand), as well as the complex interactions between reservoir management objectives. In basins where river flow is generated by snowmelt runoff, changes in air temperature can modify snow accumulation, melt, and the corresponding streamflow response. The objective of this research is to assess the sensitivity of hydropower generation to air temperature changes in snow-dominated basins. Preliminary results addressing this objective are presented for the Dworshak Dam in the Clearwater Basin of central Idaho. We developed a low-parameter model that simulates snowmelt runoff based on spatial distributions of precipitation and temperature. The model simulates snow accumulation and melt within discrete 30 m elevation zones. This approach provides a simple representation of temperature dependence on elevation and its influence on snow accumulation and melt. The model can be forced with stochastically generated temperature time series, and the simple model structure enables efficient testing of many possible temperature scenarios. We developed the model using measured temperature, precipitation and snow-water equivalent from throughout the Clearwater basin and tested it against measured streamflows at multiple basin locations. We then used modeled runoff from a basin above Dworshak Dam to drive a decision-support reservoir operations model. The operations model represents the management objectives of Dworshak Reservoir such as flood control and in-stream flows for fisheries on a weekly time step. These objectives influence the amount and timing of hydropower generation. For example, if the elevation of water in Dworshak Reservoir is drawn down to provide storage space for flood control then the overall reduction in reservoir head will lead to lower annual hydropower generation. Within this multi-objective context, we use the reservoir operations model in conjunction with the runoff model to examine how temperature-induced changes in streamflow affect hydropower generation.

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